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## Deep Searches for High Redshift Molecular Absorption

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**Abstract.** Millimetre-band scans of the frequency space towards optically dim quasars is potentially a highly efficient method for detecting new high redshift molecular absorption systems. Here we describe scans towards 7 quasars over wide bandwidths (up to 23 GHz) with sensitivity limits sufficient to detect the 4 redshifted absorbers already known. With wider frequency bands, highly efficient searches of large numbers of possibly obscured objects will yield many new molecular absorbers.

### 1. Introduction

Webb et al. (these proceedings) discussed constraints on possible variations in fundamental constants offered by quasar absorption lines. Optical studies (Webb et al. 1999; Murphy et al. 2003) find a statistically significant variation of the fine-structure constant,  $\Delta\alpha/\alpha \approx (-0.54 \pm 0.12) \times 10^{-5}$ , over the redshift range  $0.2 < z_{\text{abs}} < 3.7$ . Comparison between H I-21cm and molecular rotational (millimetre) absorption lines can yield an order of magnitude better precision (per absorption system) than these purely optical constraints (Drinkwater et al. 1998; Carilli et al. 2000; Murphy et al. 2001): a statistical sample of H I-21cm/mm comparisons will provide an important cross-check on varying- $\alpha$ . Currently, however, only 4 such redshifted millimetre absorption systems are known (Wiklind, these proceedings). To increase this number we have employed the following search strategies:

1. Deep integrations of damped Lyman-alpha absorbers (DLAs), the highest column density ( $N_{\text{HI}} \gtrsim 10^{20} \text{ cm}^{-2}$ ) quasar absorbers known. Since we observe at a known redshift and therefore frequency, optical depth limits better than  $\tau \lesssim 0.1$  are often obtained. The DLA results are discussed in detail by Curran et al. (2004).
2. Scanning the frequency space towards visually dim millimetre bright quasars in search of a possible absorber responsible for the visual obscuration.

Here we summarise our results as obtained with the Swedish-ESO Submillimetre Telescope (SEST) and Nobeyama Radio Observatory's 45-m telescope (NRO).

## 2. Results

From an extensive literature search we selected four millimetre-loud quasars yet to be optically identified (Table 1, top). For each of these we performed a

Table 1. The SEST (top) and NRO (bottom) search results.  $V$  is the visual magnitude with the Galactic extinction,  $A_B$ , given.  $z_{\text{em}}$  is the quasar redshift,  $S$  the approximate flux density in Jy at the observed frequency band,  $\nu$ , and  $\tau$  is the typical  $3\sigma$  optical depth limit (quoted for a resolution of  $1 \text{ km s}^{-1}$ , see Curran et al. 2002).

Quasar	$V$	$A_B$	$z_{\text{em}}$	Ref	$S$	$\nu$ [GHz]	$\tau$
0500+019	21.2	0.289	0.58457	2	0.5	78.30–80.90	2
...	...	...	...	...	0.5	85.50–86.50	0.8
...	...	...	...	...	0.5	112.10–113.10	0.8
...	...	...	...	...	0.4	130.00–141.40	1
0648–165	–	2.456	–	–	1.6	78.30–80.90	0.2
...	...	...	...	...	1.5	83.90–90.50	0.2
...	...	...	...	...	0.7	138.00–141.40	0.5
...	...	...	...	...	0.6	142.80–149.40	0.7
0727–115	22.5	1.271	–	–	2.9	78.30–80.90	0.2
...	...	...	...	...	2.7	83.90–90.50	0.1
...	...	...	...	...	1.5	138.00–141.40	0.2
...	...	...	...	...	1.2	142.80–148.60	0.4
1213–172	21.4	0.253	–	–	1.0	78.30–80.90	0.4
...	...	...	...	...	0.9	83.90–90.50	0.4
...	...	...	...	...	0.5	138.00–141.40	0.8
...	...	...	...	...	0.4	142.80–151.00	1
0742+103	$\sim 24$	0.111	–	–	0.6	46.90–47.50	–
...	...	...	...	...	0.4	77.25–87.50	0.9
...	...	...	...	...	0.4	88.45–89.35	0.4
1600+335	23.2	0.137	1.1	3	0.7	46.90–47.50	2
...	...	...	...	...	0.5	77.25–87.50	0.5
...	...	...	...	...	0.5	88.45–89.35	0.4
1655+077	20.1	0.66	0.621	1	1.5	46.90–47.50	1
...	...	...	...	...	1.2	77.25–87.50	0.7
...	...	...	...	...	1.2	88.45–89.35	0.3

References: (1) Wilkes (1986), (2) Carilli et al. (1998), (3) Snellen et al. (2000).

spectral scan along the line-of-sight. The high sensitivity and large bandwidth (1 GHz), combined with the possibility of observing simultaneously with two

receivers, permitted us to scan a range of  $\approx 10$  GHz in both the 2-mm and 3-mm bands. Over these ranges we reached optical depth limits in both bands sensitive enough to detect the 4 known redshifted millimetre absorbers (Table 1 cf.  $\tau \approx 0.7$  to  $\approx 2$  at  $\gtrsim 4$  km s $^{-1}$  resolution), although no  $\geq 3\sigma$  absorption features were found (Murphy, Curran & Webb 2003).

Of the remaining visually dim quasars, 10 have 3-mm flux densities  $\gtrsim 0.5$  Jy. Four of these are located in the north and with the NRO<sup>1</sup> we were able to observe the three listed in Table 1. While the 6-mm limits are poor, again at 3-mm our search is sensitive enough to detect the 4 known absorbers over the observed redshift range: For the  $J = 0 \rightarrow 1$ ,  $1 \rightarrow 2$  and  $2 \rightarrow 3$  of transitions CO, HCN and HCO $^{+}$ , i.e. the most commonly detected transitions in the 4 known absorbers, the observed frequencies give a 50% coverage for 0742+103 up to  $z \approx 3$  and 30% for both 1600+335 and 1655+077 up to the emission redshift<sup>2</sup>. The coverage for the SEST sources are discussed in Murphy, Curran & Webb (2003); for the above transitions up to 90% is achieved due to the large bandwidth and dual receiver capability.

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<sup>1</sup>The fact that each of the 6 AOSs on the NRO only covers 0.25 GHz is compensated by the high efficiency of the 45-m antenna (4 Jy K $^{-1}$  cf. 25 Jy K $^{-1}$  at SEST).

<sup>2</sup>Note that we have included the possibility of HCN or HCO $^{+}$   $0 \rightarrow 1$  Galactic absorption towards all 3 sources as well as HCN or HCO $^{+}$   $1 \rightarrow 2$  in the host of 1600+335.